

# The Economic Motivations for Clinical Information Systems

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*For three decades (1960-1990) the primary use of computers in hospitals in the U.S. was to ease the task of reimbursement for care rendered and to automate results reporting for high-volume, time-critical tests such as clinical laboratory procedures. Hospitals were regarded as independent organizations/revenue centers which could pass costs to third party payers. Beginning in the mid-eighties, U.S. hospitals were no longer reimbursed on a fee-for-service basis for many patients, but received a fixed payment regardless of the actual cost of treating a patient. The size of the payment depended upon the patients' type of illness (Diagnostically related group). This approach gave hospitals incentives to reduce costs, but did not foster a fully competitive environment. Now, in the mid-nineties, hospitals in the U.S. are seen as cost centers in an integrated health care delivery system. Within this environment, a longitudinal patient record is necessary to increase levels of communication between healthcare providers. While certain management functions remain hospital-centered, clinical information systems must now cover a spectrum of patient activities within the ambulatory and inpatient arena. Several of the leading healthcare providers use computer-based logic to alert care givers whenever standards of care are not being achieved. These institutions feel that such capability will be the real impetus to reduce cost and improve the quality of care. Based upon observations over four decades, it appears that economic considerations play the major role in determining which kinds of information systems are deployed in the healthcare arena.*

## INTRODUCTION

Computerization is a means to an end and not an end in itself. In a healthcare setting, computers should be used whenever it is possible to reduce costs or errors or to improve the quality of patient care. Computer

applications can also reduce the cost of controlling allocation of resources or achieving standards of quality. In this paper we will review the use of computers in the hospital setting over four decades. We conclude that economic considerations are the primary force which drive the deployment of information systems in the health care setting.

## THE DEVELOPMENT OF HOSPITAL SYSTEMS

Hospitals originated as places where supportive care could be administered more economically than in the home. Physicians could see many patients quickly, there was around-the-clock support in an emergency, and nurses could serve more than one patient simultaneously. Stays were typically lengthy and costs were primarily for room, board and nursing care. With the improvements in sterile techniques, antibiotics, anesthesia, surgical procedures, and intensive care units, hospitals became a focus for expensive procedures and heroic efforts to prolong life. These innovations caused the cost of hospital care to rise sharply and many large employers spread the risk by offering insurance coverage. Soon health insurance coverage for employees and their families was regarded as an expected fringe benefit. In 1965, all older Americans were guaranteed insurance coverage for hospital stays.

Until recently, the economics of the hospital business were based upon fee-for-service or cost-based reimbursement. The more procedures a patient received or the longer the patient stayed, the more the hospital was reimbursed. Naturally, a very cost effective use of computers in such an environment would be to insure that all possible charges would be collected and that billing and accounts receivable functions be automated. Hospitals could recover the investments in information systems in their fee structures. Because of this reimbursement focus,

several characteristic aspects of hospital systems evolved:

a) The data were encounter-focused for each patient. Most systems did not easily link multiple encounters for a single patient into a longitudinal record. In fact, the individual medical record number was often subordinate to the financially important encounter billing number. A fundamental application was the *Patient Admit/Discharge/Transfer (ADT)* module. This module collected insurance and demographic information and formed the basis (since per diem charges were room-based) for a hospital census application. In turn, the census application was used for directing visitors, phone calls, housekeeping, phlebotomy teams, etc.

b) Desired data usually were not collected from a healthcare professional at the point of service. Physicians, nurses, therapists, and others wrote progress notes, vital signs and orders into the paper record. Dictated reports were transcribed on typewriters and placed in the patient chart. For the purpose of efficiency, error avoidance, and reimbursement purposes, a ward clerk would use the written order to enter the requests for diagnostic tests and diagnostic or therapeutic procedures into the computer-based *Order Entry* application. One of the primary purposes of order entry was to enhance the charge capture function in the hospital. The patient also benefited from the order entry system because each request was rapidly communicated to the appropriate ancillary system in a standardized manner. The chances of omission were reduced, although in some instances the ward clerk might misread the physician's handwriting. A nurse or a doctor would generally "sign-off" on the transcribed orders to certify an accurate rendition. Generally, *Results Review* functionality was coupled with the order entry application because little extra investment was required.

Additional computer-based applications such as *Surgery Scheduling* evolved to improve efficiency, enhance utilization and to increase the accuracy of charge capture. For example, customized "case carts" were defined for each surgical procedure that a particular surgeon might perform. After a patient and procedure were scheduled, a list of surgical supplies and instruments for the procedure would be generated. A cart containing those supplies was wheeled into the operating room. Not only would the surgeon have all desired supplies readily available,

but the hospital could properly bill for every packet of suture which was used.

c). *Clinical laboratory* computer systems were the first healthcare applications to be developed on stand-alone mini-computers. The high volume of laboratory tests, the limited number of types of tests, the need for accurate linkage between test results and patients, the desire to review test results immediately and in a variety of settings, all combined to create significant advantages for laboratory automation. These results were sent back to the central order entry/results review application through specially programmed, one-of-a-kind interfaces. Based upon the success of the clinical laboratory automation, many hospitals also moved on to pharmacy and radiology management. Again the win was two-fold: the hospital accurately captured an account of the resources used and healthcare providers could see test results or medication lists for hospital patients even if the paper charts were not readily available.

d) In contrast with ADT and Order Entry (administrative) applications, several computer-based applications were developed which were designed primarily to improve either the efficiency or quality of patient care. These systems (*catheterization laboratory, ICU monitoring, pulmonary function testing, EKG interpretation, nuclear imaging*) were typically offered as stand-alone applications which did not run as part of the "Hospital Information System" offered by major vendors.

e) Because computer memory and disk storage were relatively expensive, the patient information was generally deleted or stored on magnetic tape shortly after the patient was discharged and the billing was completed.

## ADVANCED CLINICAL INFORMATION SYSTEMS

The above historical synopsis generally represents the state of hospital computing in the U.S. from 1960-1990. However, four U.S. hospitals and two commercial firms can be singled out for developing clinical information systems that were primarily focused on patient care: Beth Israel (Boston) [1], Brigham and Women's Hospital (Boston) [1], LDS Hospital (Salt Lake City), [2] Regenstrief Institute (Indianapolis) [3], HDS (Ulticare product), and Phamis. In Europe patient-focused information systems are exemplified by the systems at the

University Cantonal Hospital in Geneva [4], the University Hospital Gasthuisberg in Leven, Belgium [5], and the Leiden University Hospital in Holland [6]. The development of most of these systems started in the late sixties or early seventies. Each of these exemplary systems generated alerts, warnings and suggestions when logical criteria were satisfied by a patient's data. This capability is not available in a paper-based clinical system. These clinically focused systems integrated the wide variety of clinical applications within a monolithic architecture. By monolithic, we mean that patient and provider context is preserved as the user switches between applications. The various applications use common databases and run on a central host or hosts with a common operating system. This architecture provides a common user interface, development environment, and back-end database. There are some drawbacks to this approach, which applies not only to these groups who developed patient-focused applications, but to vendors of the traditional hospital information systems. The requirement that most (all) applications must be developed within the monolithic environment has development implications. As new development environments emerge, all previous applications must be upgraded; otherwise new software development would take place in an obsolete environment. If a customer wants applications that do not exist in the monolithic system, it is difficult to satisfy the need.

## POLICY AND TECHNOLOGY CHANGE

By the mid-eighties, the technical and policy environment changed rapidly to foster new ways of building new types of systems systems. The change in focus for applications was a result of the reimbursement policy of the U. S. Federal Government. Technological change involved the emergence of PC's (and word processing) and networks.

The U.S. Federal Government had seen unabated growth in costs for healthcare for the elderly (Medicare) since it agreed to pay the hospital costs for that group. In an attempt to stem that growth, the government began to reimburse the hospitals' according to the particular type of illness or procedure the patient had regardless of how many days the patient stayed in the hospital or how many diagnostic tests or procedures the patient received. The federal reimbursement for each patient depended

upon the Diagnostically Related Group (DRG) to which the patient was assigned by coders in the hospital's medical records department. This assignment was based on retrospective analysis of the data available in the paper-based patient record. Thus, immediately, hospitals in the U.S. focused on *Computer-based Coding* assistance and *DRG Grouping* applications. Small changes in the patients' coded status can have significant impact on reimbursement: If a 67 year old female Medicare recipient is admitted for treatment of asthma, the DRG assigned for this diagnosis is 097, with an average payment of \$4,531. However, if the patient has Chronic Obstructive Pulmonary Disease as well as Asthma, the DRG assigned would be 088, with an average reimbursement of \$7,455. In order for the hospital to assign the correct DRG and receive accurate reimbursement, it is important to document COPD when it is present. In other words, clinical data were needed to justify reimbursement.

In some states, such as New York, the care for all patients (not just the elderly), was reimbursed according to the DRG payment scheme. Before this change in reimbursement policy, if a hospital performed an additional radiological examination, the hospital earned more money. After the change, if the hospital performed the extra examination, they incurred the technician and film costs, but received no additional reimbursement. For the first time, this policy gave hospitals an incentive to limit expenditures on behalf of a sick patient. Up to the current point in time, these reimbursement changes only address hospital incentives. The patient does not have an economic incentive to limit expenditures as he or she is covered by traditional insurance (reasonable and customary charges are paid); and the physician is paid additional compensation if he or she delivers more care.

In this new environment, hospitals suddenly began to cut costs. To see where the hospital was spending money, the data from the existing charge capture systems were pooled into what became known as *Executive Information Systems*. Using such a system, the executive can also determine whether the hospital makes or loses money for each type of DRG and for each individual physician who admits patients. In this sense, the existing order entry and billing systems continued to provide value to the hospital.

Even though they would use the computer to review test results, physicians generally resisted the use of

automated information systems for data input because the user interface was not efficient for them. The paper chart remained the primary repository of information which described the patient's condition, and response to therapy for hospital based episodes of care.

## TODAY'S ENVIRONMENT

The executive information systems (as well as studies by health economists [7]) showed that resource consumption for patients with similar illnesses varied widely from physician-to-physician, hospital-to-hospital and region-to-region. For hospitalized patients, the coarsest measure of resource consumption was length of stay. When hospital administrators saw the variance, they began to realize that in many cases the length of time a patient stayed in the hospital could be cut substantially. This push, which initially did not need heavy computer support, led to two new major issues: hospital occupancy rates and questions about compromised quality of care. The decreasing rate of bed occupancy (which occurred because length of stay was cut for the same number of patient admissions) stimulated hospitals to seek outcomes data because they began to compete with one another for patients to fill the beds. The most significant competitive metric other than price is patient outcome (most payers will not pay a significant premium for friendly service).

When people tried to decide whether a patient was being discharged so rapidly that their care was compromised, they found that there were very limited data which could be used to answer such questions. Because most hospital systems did not have coded data about anything but laboratory tests and medications, it was very difficult to measure outcomes. Did a patient receive better treatment and have a better outcome at a major academic medical center than at a community hospital? The answers to this type of question lie in truckloads of mostly handwritten, paper-based notes. Decades of collecting episodic data primarily for generating patient bills had not generated enough information to show whether a new mother should stay in the hospital one day or two weeks. Many hospitals could not measure their true post-operative wound infection rate or the number of adverse drug events.

It was even more difficult to compare one hospital's data to that of another hospital. The U.S. Government's Healthcare Financing Agency (HCFA)

and some states who mandated reporting ended up with databases which could be used to compare hospitals' and physicians' relative performance. Using data obtained by mandated reporting regulations, New York State has been able to publish mortality rate-by-surgeon information for those patients undergoing coronary artery by-pass surgery. Because of the clamor by physicians and hospitals who did not fare well in these comparisons, it was necessary to adjust those gross mortality rates by "severity of illness." Most hospital information systems cannot generate such information without resorting to manual extraction of the data from the patient charts. Since the DRG classification is determined in the same manner, administrators now are seeing an economic incentive to invest in clinical information systems which acquire patient based clinical information at the point of care. Additionally, there are two other incentives:

- a) the ability to generate alerts, suggestions, and reminders, and
- b) the ability to encourage the provider to follow a "critical pathway" in deciding how to best care for the patient and to track the compliance with those standards.

This latter ability could change the way medical care is delivered by decreasing omissions and non-efficacious diagnostic tests or therapies. The resultant cost savings are potentially significant because allocation of resources is addressed. The major disincentive is the reluctance of physicians to enter data into the computer.

In summary, the current decade has seen major shifts from administrative hospital information systems, to systems which are used by the physicians, nurses, and other healthcare providers as part of the process of delivering healthcare (i.e., Clinical Information Systems). The motivation for investing in these clinical systems is now economic. Previous generations of hospital information systems which focused entirely on charge capture ignored the ultimate source of resource allocation - the individual physician. At the point of service, physicians, nurses and other healthcare providers must be encouraged to help the hospital manage allocation of resources. The Regenstrief group showed a reduction of 12.6% in hospital charges by using such a system [8]. By using clinical information systems, an organization gets better outcomes data and providers receive immediate alerts when standards of care (from a quality and cost perspective) are not being achieved. Perhaps most importantly, as the physician becomes dependent upon use of the Clinical Information

System, the administrator may gain some level of control over physician behavior. The physician-based, computerized order entry systems can give reminders and suggestions as the physician writes orders to allocate resources. From an administrative perspective, this sort of control is desirable because, in the absence of guidance, a highly autonomous group of individuals demonstrates wide variation in the way resources are allocated. Individual judgment may or may not be at odds with established standards of care.

Given the physicians' long-standing tradition of autonomy, and the historical difficulty in making computer data entry palatable to physicians, the practical success of clinical information systems is still questionable. What are the critical elements that will motivate physicians other than residents in training to enter orders (resource allocation) and progress notes (critical pathways, care plans, etc.) into the computer instead of writing them on paper or dictating them for transcription.

In our mind there are several reasons that physicians, nurses, and other caregivers will use well-designed clinical information systems:

- 1) Presentation of data about the patient in an organized, comprehensive manner with instant access any time, anywhere, to data which are needed to care for a patient. Such information would include immunization history, drug allergies, status of preventative measures, laboratory and other test results, specialist's referral reports, problem lists, visit notes, discharge summaries, surgical procedures, real-time vital signs and images. Reliable, accurate, well-organized information will definitely help the physician, his/her staff, nurses, or healthcare workers save time and reduce errors. The challenge is to gather enough of this information in an electronic format to make it the critical mass repository of desired patient information. It is certainly easier to organize and present the data in the electronic version than asking someone to "flip" through a paper-based chart. Confidentiality issues must be addressed in a different manner than when dealing with paper records that can only be in one place at a time. However, it appears that those issues can be adequately addressed. Not all data need to be entered by professionals. Information that is not immediately needed to determine if standards of care are being achieved could still be dictated and transcribed in a timely manner (e.g., discharge summary). Promising technologies such as hand held tablets and voice

recognition are gradually becoming acceptable from a performance stand point.

- 2) Highly convenient availability of cogent sources of additional expertise or knowledge as part of the system. The use of Medline-based literature searches has been warmly embraced by caregivers. Uman, Manning, and Covell[9] concluded that physicians wished they had additional information during one-third of their patient office visits. The explosion of information resources on the World Wide Web (Internet) promises the desired content. The challenge is to filter the information and present only that which the user is most likely to desire when caring for a particular patient with an unique set of problems and challenges. Promising prototypes of such work are beginning to be used, although it is likely that another decade will pass before we have done enough research to enable "knowbots" or "mediators" to totally automate this process.

- 3) Electronic synchronous and asynchronous communication with colleagues and patients. E-mail is a wonderful way to leave a note to a colleague who is covering a patient for the weekend. Video conferencing is just beginning to pay demonstrated dividends. It is technically possible today to hear a previously dictated radiologist's opinion about a patchy infiltrate while seeing her move a cursor on the image. Integrating such sources of information into the clinical information system will clearly improve a physician's ability to get a "wet reading" of an ICU chest film. Over the next decade, patients will also receive access to these information systems and communicate with providers electronically.

- 4) Perhaps the most economically compelling application of computers within the emerging healthcare environment is the automated generation of alerts, reminders and suggestions when standards of care are not being achieved. All of the previous three benefits can be achieved to some degree with paper charts, books, telephones and letters; the computer primarily increases the efficiency and convenience of achieving those ends. The mechanism for achieving real-time quality control, however, can be achieved realistically only in an electronic environment. The use of manual oversight to encourage compliance is prohibitively expensive, obtrusive and subject to the same human foibles that one is seeking to avoid. Even though "second opinions" are mandated by insurance companies for some big-ticket items, the manual approach does not

scale to the myriad of hour-to-hour tasks and decisions that can improve the quality and efficiency of care.

In the case of automated reminders and alerts, the computer adds real additional value. Most physicians make mistakes infrequently. When their decisions are in accord with established standards of practice, the care providers are generally unaware that their actions are being critiqued by the computer. It is only when there is a deviation, that a message is delivered to the physician. From our perspective, the most exciting aspect of the computer-based decision-making capability is the ability to structure the logic of a "critical pathway" as a series of rules which will fire independently whenever criteria are satisfied. Using this approach, it is not required that a patient be followed using a branching protocol that loses significance when unexpected events take place. Rules from three or four different protocols/pathways could generate simultaneous and valid suggestions if the patient's clinical condition warrants such suggestions. Clinicians and administrators can choose to focus on the "meaty" parts of a critical pathway, rather than requiring that every aspect of a patient's care be addressed. Automatically generated alerts, suggestions, or warnings can also be used to create lists of pending crucial tasks which are specifically germane because the patient's clinical data satisfy logical criteria. This dynamically generated task list based upon patient condition is a totally different approach to care plans than a "one size fits all" flow chart (whether paper-based or electronic).

The groups at Beth Israel, Brigham & Women's, LDS Hospital, Columbia-Presbyterian, and Regenstrief Institute have demonstrated the ability of computer-generated messages to alter provider behavior. From a hospital executive level, adherence to the critical pathway gives two-fold benefit: the patient is treated in an efficient and cost-effective manner and standards of quality are maintained. Discharging sick patients prematurely may save the hospital money, but there must be built-in safeguards for quality of care which counteract the newly motivated tendencies to cut costs.

5) The final benefit that information systems will begin to provide is a longitudinal patient record. Whereas in the past reimbursement was based upon an acute episode, in a vertically integrated healthcare provider system, keeping the patient out of the hospital will save money. Hospitals will become cost centers, not revenue centers. Prevention will become

more economically attractive. Hospital information systems will have to feed the longitudinal patient record. If the hospital sees patients from several healthplans, the information system must communicate with several different types of longitudinal records. Our current efforts to develop standards for message passing and vocabulary will greatly accelerate over the next decade.

## **TECHNICAL ASPECTS OF CURRENT HOSPITAL INFORMATION SYSTEMS**

To accomplish the economically motivated patient-care goals we have described above, we believe that clinical information systems will be created by interfacing and integrating many disparate applications. These applications will not all come from a single vendor or run on a single computer. A healthcare organization must create an information architecture that is not based upon the offerings of a single vendor. Simborg [12] authored one of the earliest published descriptions of the distributed architecture paradigm. Integrating patient data from multiple sources may be the only alternative (as opposed to a homogeneous monolithic approach) in an era of mergers and consolidations of healthcare facilities. Integrating patient data from multiple sources may be the only alternative (as opposed to a homogeneous monolithic approach) in an era of mergers and consolidations of healthcare facilities

The basic information architecture should depend upon a network of desktop computers which can run application programs based within any of multiple application hosts which are also connected to the network. The network architecture should allow for secure transmission of data and passwords. Further elements of the network architecture include a repository (long-term patient data base), protocols for sending messages between various sources of information (e.g., TCP/IP, CORBA and HL7), a dictionary which translates information representation (terms or codes) between various applications, and an interface engine (database interface) which receives messages and queries and routes them to the correct destination(s). Work is proceeding to improve standards for exchanging data between applications [10,11,]. In addition to HL7, which is becoming ubiquitous in the U.S., EDFACT is common in Europe. Other emerging data exchange standards include CENTC 251 (PT004), IEEE//MEDIX, ANSI, NCPDP and DICOM. HL7 is a rapidly maturing standard; in some cases (clinical

laboratory and demographics) the format is extensively specified. In other cases, one simply uses the HL7 header as an envelope to enclose information which must be parsed by a data access module.

The repository must be flexible, scaleable, and extensible so that new data types can be conveniently added. Another requirement is acceptable response time both at the server and the network level for data queries. Automated decision-making capability imposes an order of magnitude more stringent response time requirements than is necessary for simple data review. The role of the dictionary is to map terms or codes used in the various applications into a common representation. This mapping is typically accomplished as data flows through the interface engine. Dictionaries are beginning to emerge as a result of the leadership at the U.S. National Library of Medicine and the Public Health Services in the United Kingdom. The National Library fostered an approach in which medical entities can be related by semantic and hierarchical links and qualified by local and global attributes. The lists of entities for inclusion in the dictionary are quite comprehensive for the domains of clinical laboratory and pharmacy. SNOMED, ICD, and Reed, are vocabularies which remain to be integrated into the appropriately-modeled semantic structure. The good news is that one does not need comprehensive coverage within the dictionary to begin storing data. One can create dictionary content as additional applications are added. The bad news is that robust, institution independent tools and skills for editing, managing, and merging the dictionaries are not yet available.

Advantages of this architectural approach are multiple. Data may be collected in any interfaced application. Those data are communicated to the longitudinal patient database which is logically centralized but can be physically distributed. Any application can access data collected by other applications. It is not required that the user applications be constrained to reflect monolithic hardware or software conventions. There might be multiple results/review or data entry programs, but each such application can get the data as long as it uses the standard interface protocols. Piping data to a logically central hub also enables the automated decision-making aspect to function. As each packet of data is stored in the repository, the event monitor looks into its "knowledge-base" to see if there are any rules which should be evoked to evaluate the

new data. Additional data required by the logic are also retrieved from the database. If the criteria are satisfied, an appropriate message is generated. This alert or suggestion can be displayed as part of a results review screen, or actively be transmitted by opening a process on a multi-tasking workstation, by e-mail, by an autodial beeper or by fax. Most groups now realize that a repository which is separate from any particular application has performance and longevity benefits. In fact, there can be multiple repositories which can simultaneously exist. Queries received by the interface engine are translated into database access modules (or objects). This library of modules could be rewritten to query a new database and the existing application programs would not realize that they were getting data from a different source.

A European funded CENTC-251 committee is working to abstract the architecture for clinical information systems. This reference architecture [13] would allow development of components which could be used together in a plug and play fashion while achieving the same level of integration afforded by the monolithic systems. Systems integrators would be able to purchase various components from various vendors and have competing versions of specific components from which to choose. Accomplishment of these far reaching goals would allow developers to pool their efforts to develop information systems and dramatically shrink the time which is currently required to construct clinical information systems.

How does one obtain such a hospital information system? In previous environments, one selected a turnkey vendor. In today's environment, one must develop in-house integration expertise or hire a systems integrator. There is a need to develop a resource pool to manage the disparate systems. These people will have a far different mix of skills than needed when dealing with a single vendor system. There are several commercial sources for the systems components, interface engines, and repositories. From a technological standpoint, there are several steps to be followed as one implements a clinical information system:

1. Establish a network of desktop and host machines. Avoid proprietary protocols;
2. Implement e-mail;
3. Select fundamental hospital applications (Registration, billing, clinical laboratory,

- radiology, pharmacy, and results review) which can send and receive HL7 messages;
- 4. Implement a repository;
- 5. Use an interface engine to route data messages between various applications;
- 6. Establish a data dictionary for defining the content of the patient record in a coded format;
- 7. Establish a front-end scripting environment for the workstations that allows seamless access to any of the applications. With a WWW browser, Perl and Java, it is becoming easier to create such an environment;
- 8. Add information resources: Medline, pharmacy handbooks, procedure manuals, etc.;
- 9. Encourage domain or department specific applications;
- 10. Implement a decision-making application;
- 11. Facilitate physician-based entry of orders and encounter or progress notes.

### THE FUTURE

By the time these technological steps are completed, the next round of the healthcare revolution will have occurred. Hospitals will no longer be reimbursed according to the fixed DRG rate, but will bid to healthcare payers to provide care for the patient at a negotiated price. This will reward the cost-efficient hospitals, but payers and patients will demand evidence of quality. It may finally be possible to measure patient outcomes in a meaningful way. Programs to analyze the clinical data will become available.

The final twist involves emerging motivations to keep the patient out of the hospital entirely. In the previous model, physicians and hospitals earned money when the patient was sick. Insurers could raise premiums to cover the costs of care. The trend now is to pay providers a certain fee to care for a population whether they are sick or healthy (capitation). In the emerging capitated environment, "at risk" providers would make money if they can keep patients out of the hospital. This may mean that the information system will be extended into the home. At the very least, the hospital data would be interfaced into the information system of vertically integrated healthcare providers.

In the past, hospitals have taken the initiative in building information systems because they had a critical mass of financial resources and a financial benefit to be gained. It was also the fact that hospitals could pass the costs of their information systems onto the payers. In the new environment, the deployment of information systems will need to be financially justified to an extent never before encountered. Hospitals have more incentive than ever to reduce costs. Information systems must contribute to the efficiency and quality of care in an economically meaningful way. The only problem with this scenario is that the cost savings are likely to come from the computer-based decision-making applications. There needs to be a critical mass of physician use and acceptance before payback. The noteworthy clinical information systems referenced in this document have all taken fifteen to twenty-five years to reach the point where they can demonstrate that payback. Based upon the experience at Columbia-Presbyterian Medical Center, the use of the distributed, interfaced architecture may cut that time by a factor of three. However, five to eight years is still a long time to wait for payback. If the reference architecture being investigated in Europe or the Andover initiative bear fruit, the time to completion may be further shortened.

In the future, it is likely that there will not be Hospital Information Systems, only information systems located in hospitals. It appears that these systems will become nodes which feed a longitudinal patient record being controlled by a vertically integrated healthcare provider. These systems will be built of modular components that are integrated across multiple settings (including the home) in which the patient receives care. Computer-generated real-time critiquing will be the value added capability that will justify investments in information systems. This automated decision-making capability will enable healthcare organizations to control resource utilization and to maintain or improve quality by implementing logical criteria contained in critical pathways, practice guidelines, and care plans. If our systems can meet that challenge, we can finally achieve the potential accomplishments that were foreseen more than three decades earlier.

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